FIG.1

Derivation of numerical data of minutia ridge shap
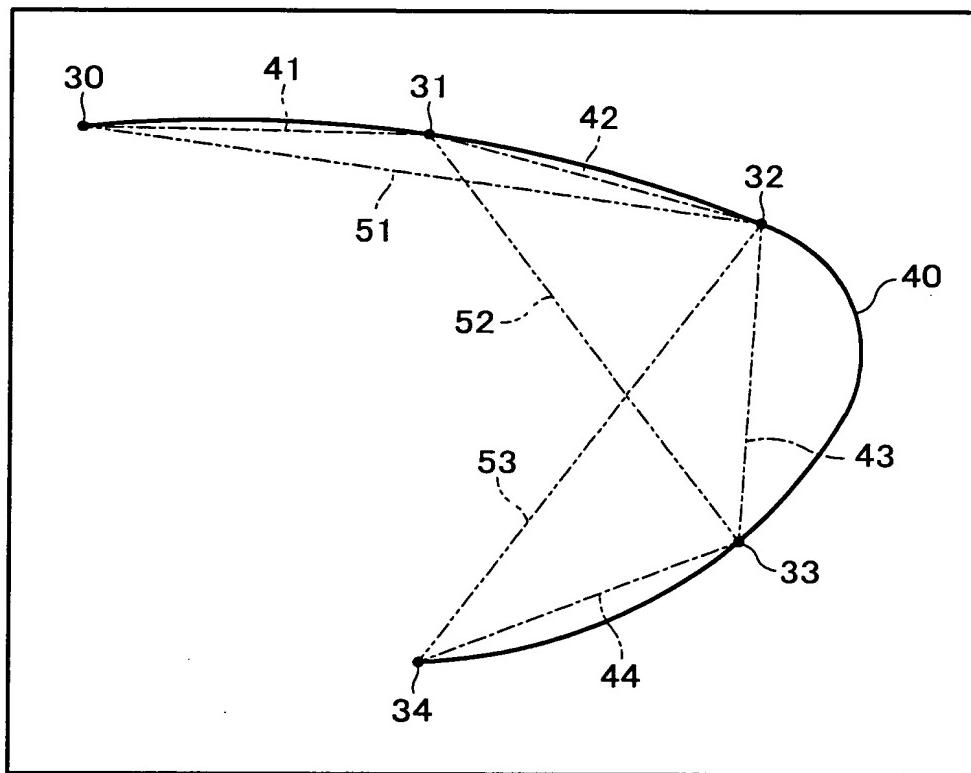
FIG.2

Curve to be recognized moves and rotates
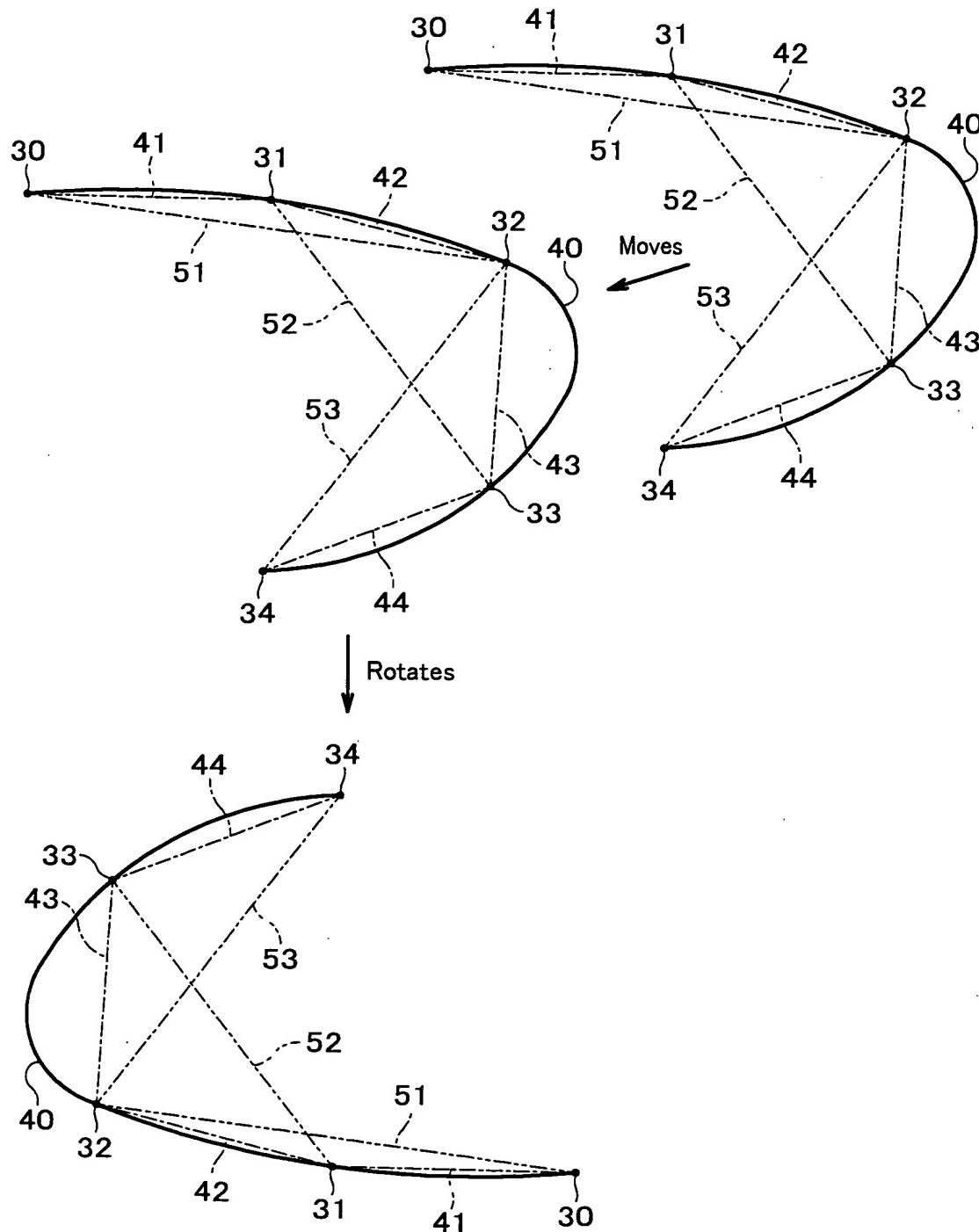
FIG.3

Principle to calculate approximately coordinates of measure points, which locates between grids
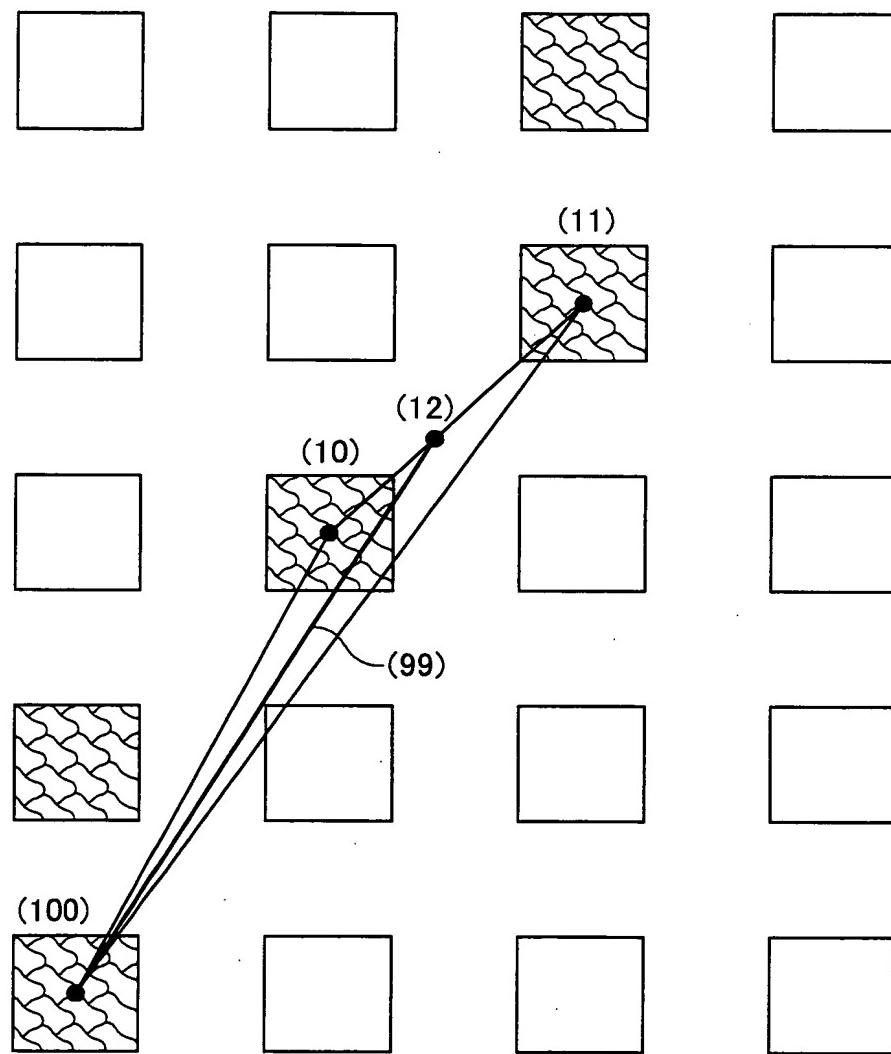
FIG.4

Curve shape system using curvature and ridge direction
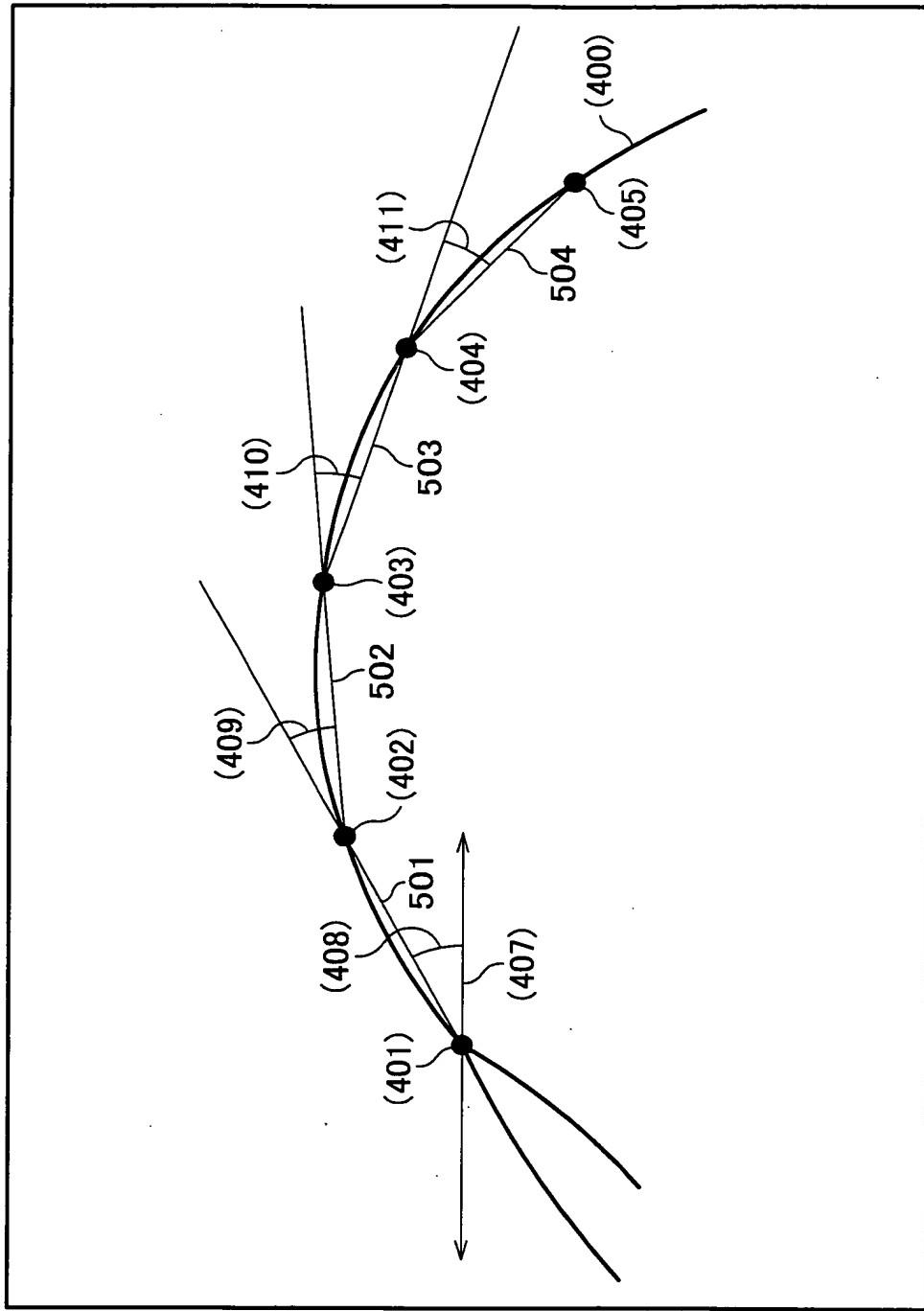
FIG.5

Algorithm for extraction of extract true minutia
thinning operation and reverse operation between black and
white over black and white binary image
Input original black and white image

S7 — Thinning operation

S8 — Compensate block of false minutia

Black and white reversal process — S70

S72 — Twice?　No

Yes

Extraction of true minutia
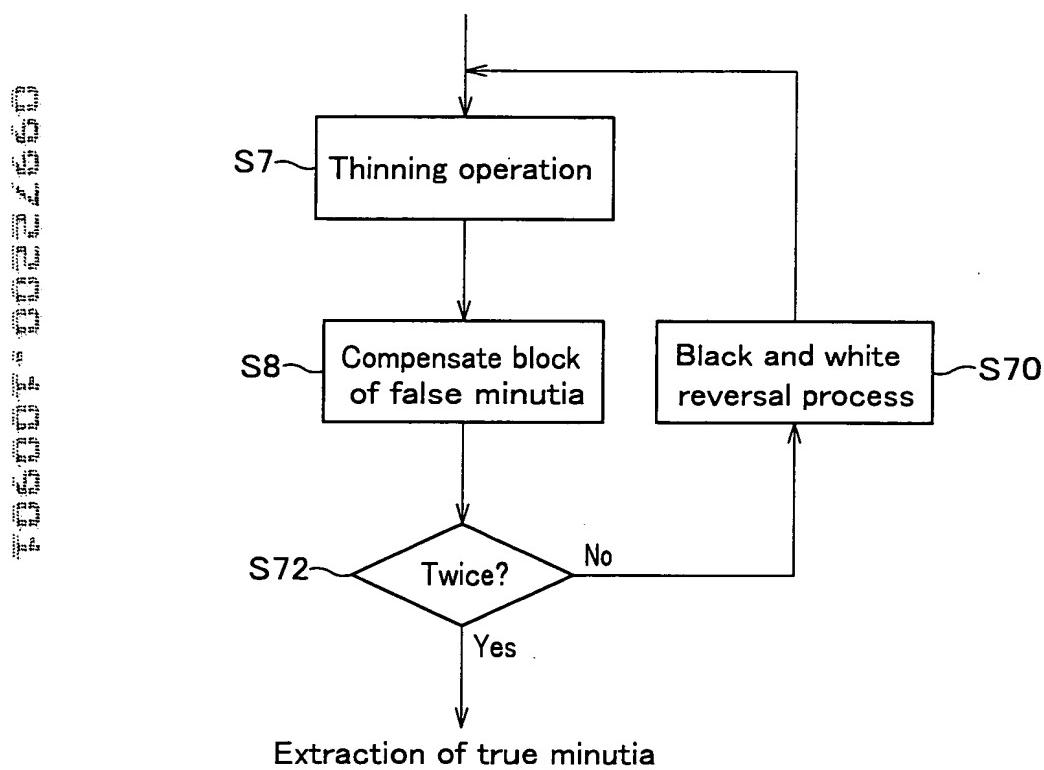
FIG.6

Algorithm for extraction of true minutia including improvement of gray scale image

Input image

S3~ Binarization

S4~ Detect ridge direction

S5 Improve gray scale image

Binarization ~S6

Tinning ~S7

Compensate block of false minutia ~S8

Extract true minutia ~S9

Output feature extraction data
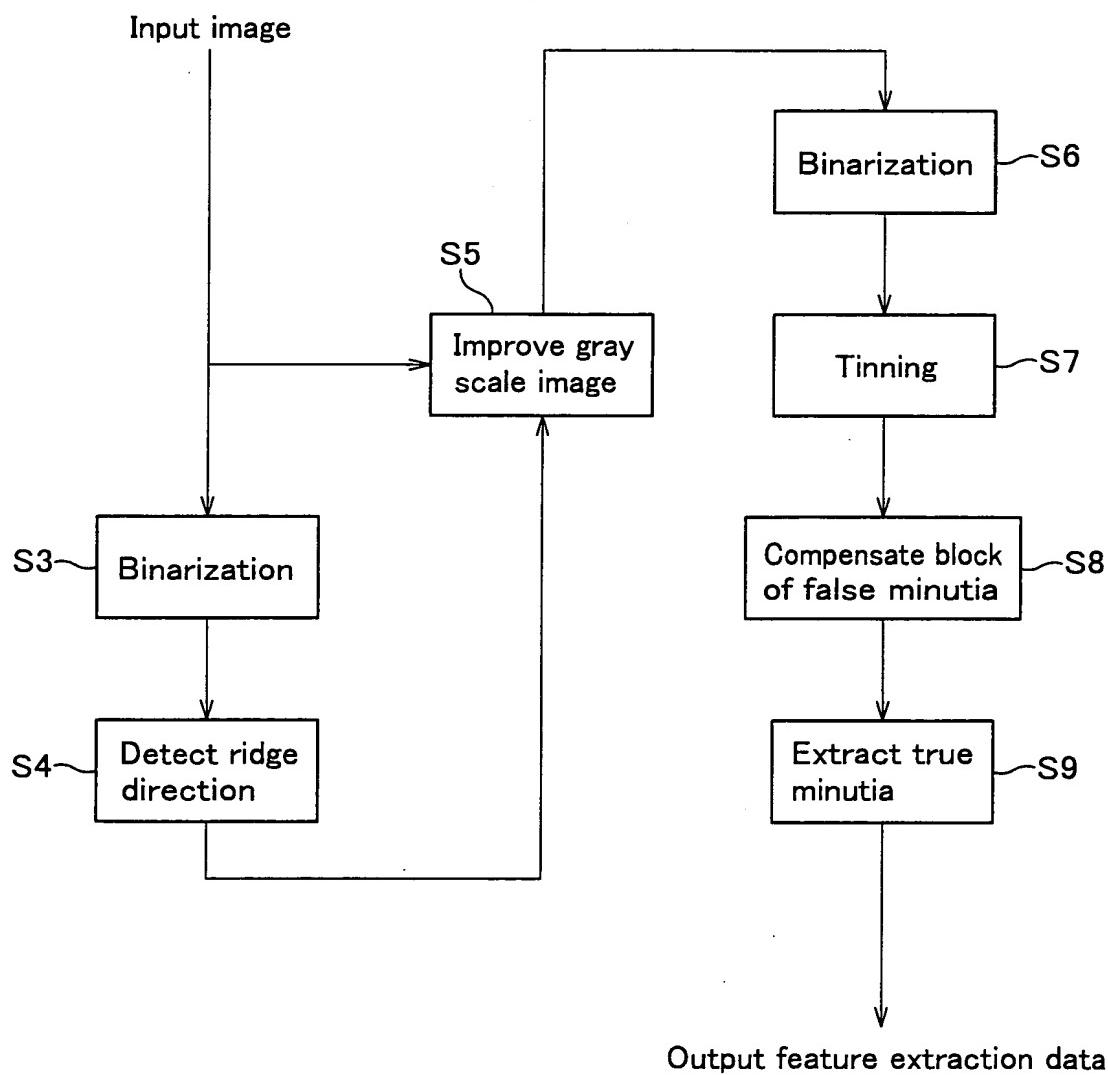
FIG.7

False feature point

(a) Two ending minutia close to each other, which posses the same directions as their minutia ridge shapes
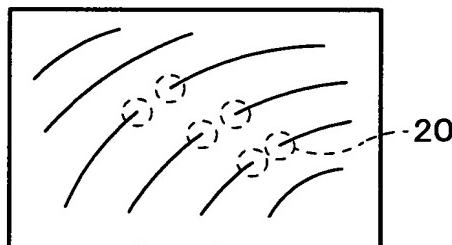
(b) Ending minutia near a bifurcation point
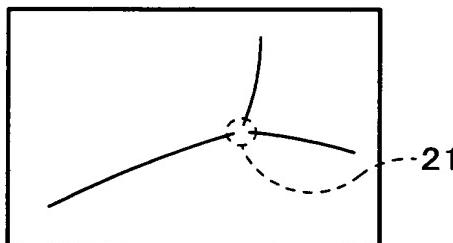
(c) Ending minutia near boundary of image
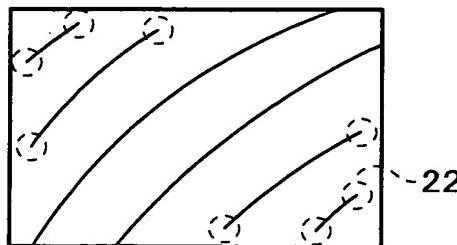
FIG.8

Extraction of minutia by thinning and reverse operations between black and white over black

(a) Black and white image before treatment

(b) Intermediate extracted minutia

Tinning →
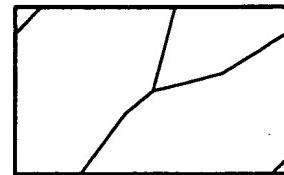
Reverse operation ↓

(c) Black and white reversal image

(d) Extracted minutia after final treatment

Tinning →
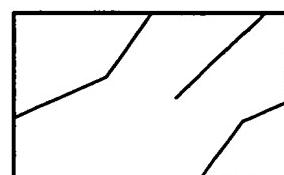
FIG.9

System for fingerprint authentication with secondary feature

Secondary ridge shape (RS3)

Secondary minutia (94)

Secondary ridge shape (RS4)

Axis vertical to direction of minutia ridge (X1)

Secondary ridge shape (RS2)

Secondary minutia (93)

Original minutia (91)

Secondary minutia (95)

Secondary minutia (92)

Secondary ridge shape (RS1)

Axis of direction of minutia ridge (Y1)
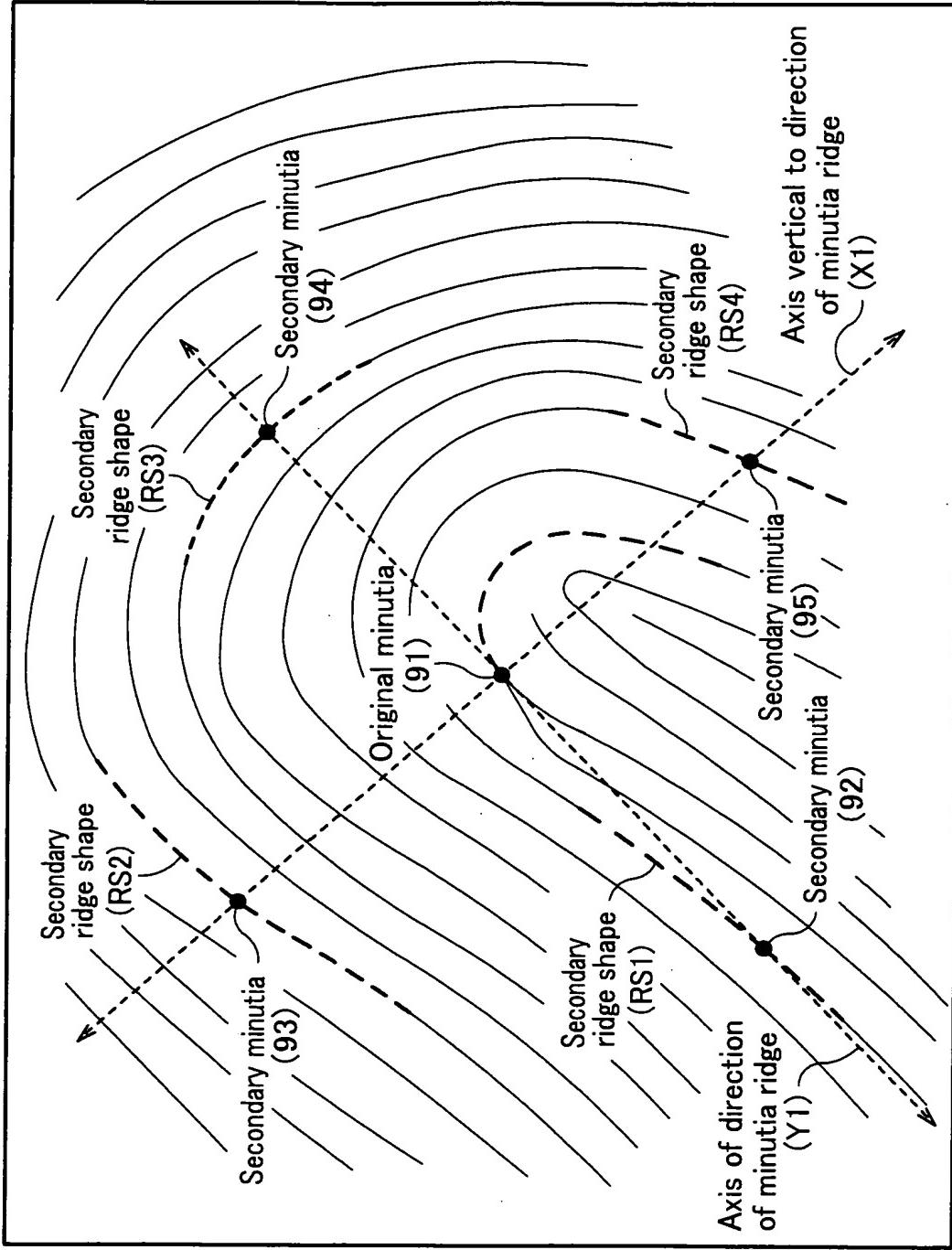
FIG.10

Judgment of removal of false minutia utilizing scalar product
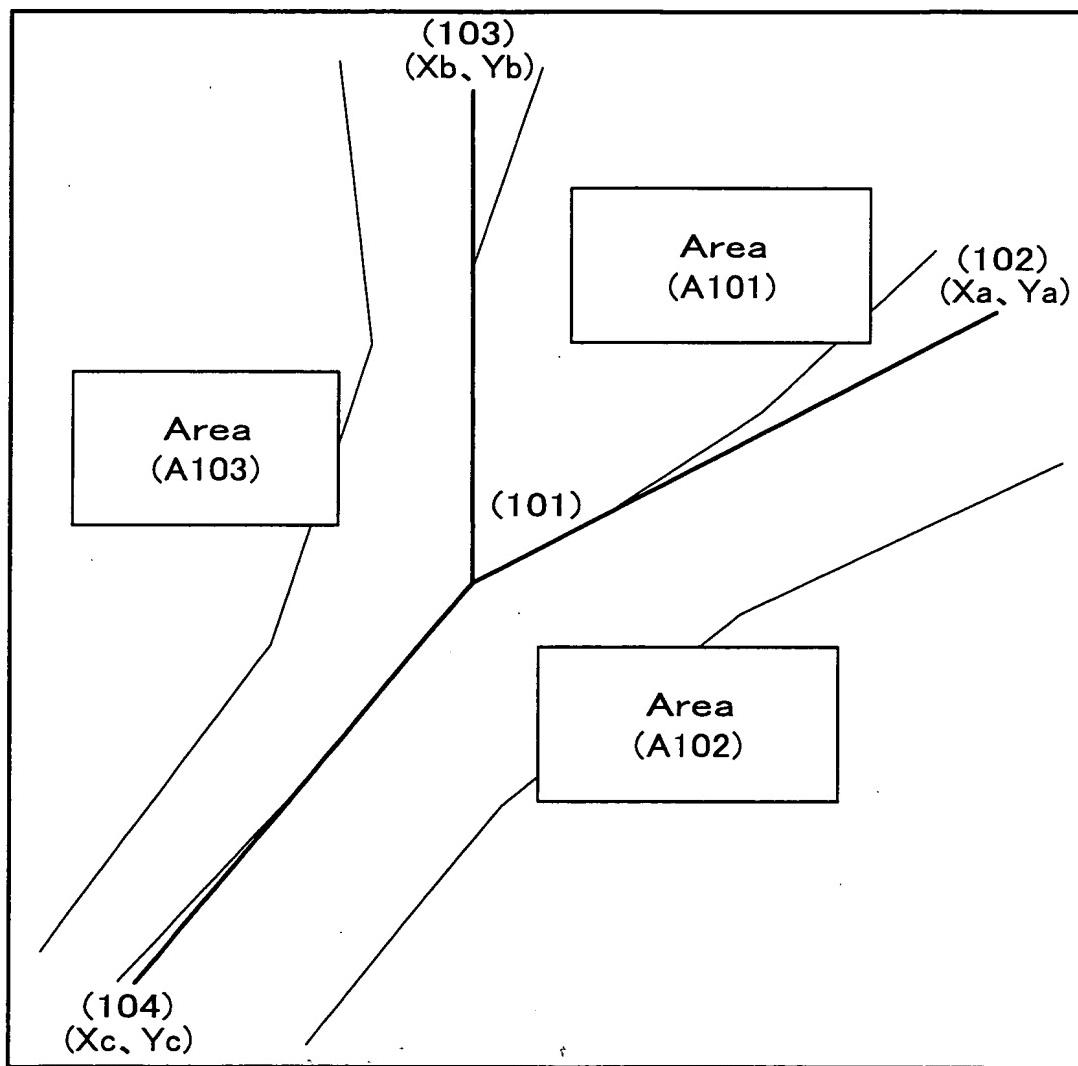
FIG.11

Memory area stores accumulated similarity measure in collation
without compensation of difference of minutia pair in positions

Difference in positions of minutia =
Accumulated similarity measure of minutia pair with
difference (1,1) in positions of minutia

	18	33	25	1	
	23	259	20	3	
	15	22	14	2	
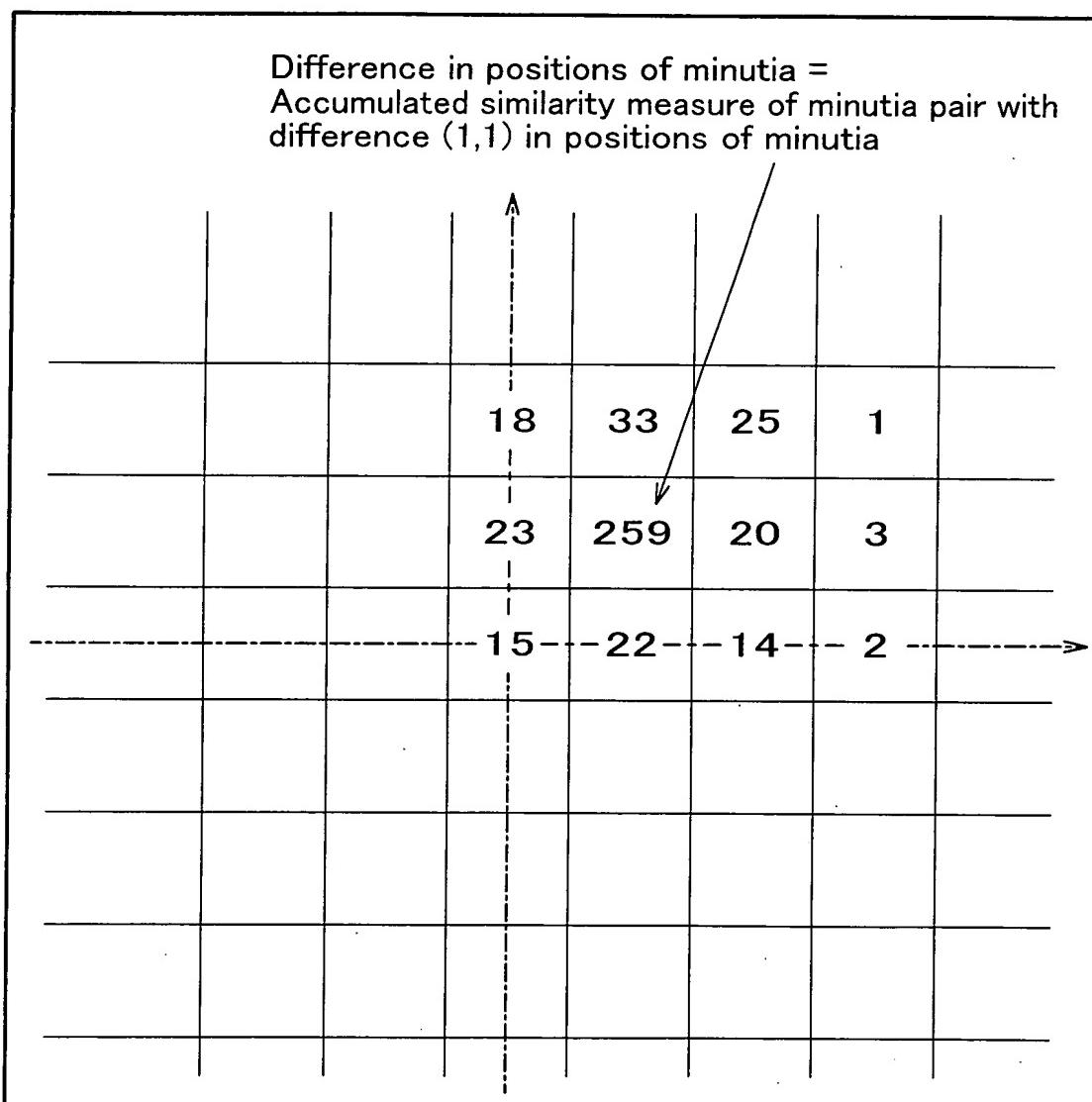
FIG.12

Algorithm of feature extraction for recognition system by use of raster scan image capture

Start

S1 — Input image from TV camera (Raster Scanning)

S92 — Store a block data of partial area in a frame

S93 — Perform feature extraction processing

S94 — Store feature data

S95 — Confirm termination of whole image process — No

Yes

End
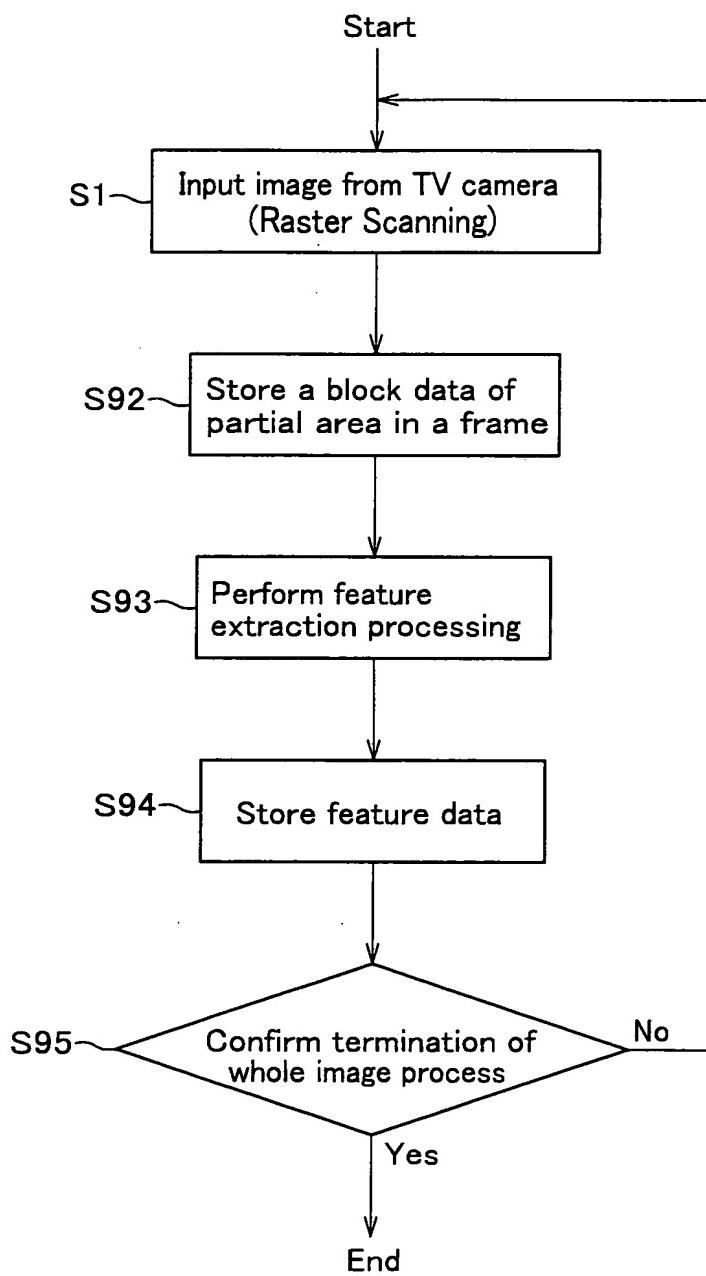
FIG.13

Algorithm for finger authentication system

```
                                                    ┌──────────────┐
                                                    │ Binarization │─S6
                                                    └──────────────┘
                                              S5           │
   ┌─────────────┐                                         ▼
S1─│ Input image │         ┌──────────────┐         ┌──────────────┐
   │from TV camera│        │ Improve gray │         │   Tinning    │─S7
   └─────────────┘         │ scale image  │         └──────────────┘
          │                └──────────────┘               │              S70
          ▼                                                ▼         ┌──────────────┐
   ┌─────────────┐                                  ┌──────────────┐ │ Reverse Black│
S2─│Block thinning│────────▶                    S8─│Compensate block│ │  and white   │
   └─────────────┘                                  │of false minutia│ └──────────────┘
          │                                         └──────────────┘       ▲
          ▼                                                │            No  │
   ┌─────────────┐                               S72─◇ Twice? ◇────────────┘
S3─│ Binarization │                                        │
   └─────────────┘                                        Yes
          │                                                ▼
          ▼                                         ┌──────────────┐
   ┌─────────────┐                                  │ Extract true │─S9
S4─│ Detect Ridge │                                 │   minutia    │
   │  Direction   │                                 └──────────────┘
   └─────────────┘                                         │
                                      No                   ▼
                          ◇ Confirm termination of  ◇─S95
                          ◇  whole image process    ◇
                                                          │
                                                         Yes
   ┌─────────────┐    On registration                    │
S75─│ Storage in  │◁ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─               │
   │ database of  │                                  On matching
   │ fingerprints │                                       │
   └─────────────┘                                        ▼
          │                                        ┌──────────────┐
          └─────────────────────────────────▶     │Matching process│─S74
                                                   └──────────────┘
                                                     │           │
                                                     ▼           ▼
                                               Not Matched   Matched (Matched Registration No.)
```